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Supporting Online Material for

Chimpanzees Are Rational Maximizers in an Ultimatum Game

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Other Supporting Online Material for this manuscript includes the following: (available at www.sciencemag.org/cgi/content/full/318/5847/107/DC1)

Movies S1 and S2

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This file includes:

Methods

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Figs. S1 and S2

References

Supplementary Materials for

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Methods

Thirteen adult and juvenile chimpanzees from a single group were individually familiarized with the test apparatus. Subjects who had reached criteria for pulling one tray with ten raisins in two dishes – as opposed to a tray with nothing – completely to the cage mesh from the starting position in at least 10 of 12 trials across two successive sessions were included in testing. Individuals took as little as two and as many as ten sessions to achieve criteria; two never succeeded within 12 sessions and were not tested. Subjects were randomly assigned to either proposer or responder roles for the first half of the study then switched after having played against all potential partners. Each responder played against five proposers; proposers played against four to six responders. In this way, each pair of individuals interacted twice, with roles reversed, but only after each proposer and responder pair interacted once. Orders in which pairs were tested was randomized. For each game, the potential number of trials for all responders was 55 (11 responders x 5 proposers); trials in which the proposer did not make a choice were excluded from the analysis. There was no effect of order on any of the parameters measured. All trials were videotaped from three positions (responder, proposer and apparatus). In addition to proposer and responder choices, responder arousal, defined by observable displays and tantrums (*S1-3*), was also coded. A blind observer coded a random selection of 20% of trials (all Cohen's $\kappa > 0.95$) and the second author coded 25% of test trials for responder arousal (100% agreement).

Testing began with both subjects in their respective cages. The experimenter put four pre-baited dishes with raisins on the two trays of the apparatus. Proposer access to the rope was blocked by sliding Plexiglas panels and the rods for the responder were out of reach. The experimenter left the room in all trials – except when it was necessary to distract dependent offspring – and then released the locking mechanism for the sliding panels.

Proposers could choose one of two trays by first sliding a small Plexiglas panel aside to access the end of a rope. The single length of rope was attached to the two trays such that pulling one end of the rope caused the other end to be pulled out of reach. The rope, when pulled, drew the chosen tray halfway toward the cages. To complete the choice, the responder could pull a rod attached to the tray that was previously out of reach. Both proposer and responder could then reach their respective food dishes and eat the raisins. Responders could reject the offers by not pulling the rod within one minute of the proposer's offer, resulting in neither subject being able to reach the food dishes. On no occasion did proposers or responders receive food unless both the proposer rope and the responder rod were pulled. Once the trial was over (either after the subjects had eaten from two of the four dishes on acceptance, or from none on rejection) the experimenter would remove all food dishes and leave the room before resetting the apparatus. Games (2/8, 5/5/ 8/2 and 10/0) were counterbalanced in order so that each subject received each game first within a session at least once. Tray positions were also counterbalanced. Responders had a total of 20 test trials (5 of each game) over the course of the study.

Subjects were given discrimination probe sessions before, alternating with, and after test sessions on separate days. Subjects were alone in their respective positions with the door to the adjacent cage closed and the trays baited as in the test (i.e., four trials); the tray chosen by proposers was pushed the remaining distance by the experimenter, and for responders both trays were first pushed halfway by the experimenter and the responders could then pull only one of them completely. Responders had a total of 20 discrimination probe trials (5 of each condition) and proposers had 16-20 trials (four to five of each condition); the number of probe trials corresponded to the number of test trials, which varied for proposers and responders. Single inhibition probe trials were given at the start of discrimination probe and test sessions; responders were alone and the experimenter pushed the trays – both of which were baited 5/0 (i.e., nothing for the responder) – halfway, allowing subjects to pull either or both. In a follow-up study (two sessions, six trials per session), while alone with the door between the two cages open but with visual access to the apparatus from the opposite cage

blocked, chimpanzees could choose between a tray baited with 2 raisins in the dish in front of them and 8 raisins in the opposite dish, or a tray baited with 2 raisins in each dish (2/8 vs. 2/2 for proposers, and 8/2 vs. 2/2 for responders). Chimpanzees remained in the role which they had last played during the test and were only tested in that position (proposer N = 6, responder N = 5).

Comparative analyses were performed with Friedman's nonparametric and planned Wilcoxon's signed rank analyses. One-sample t-tests were used for comparisons to chance. All analyses were two-tailed.

Results

There was no difference in rejections of 8/2 offers by responders among any of the games (2/8 versus 5/5 – Wilcoxon test: $T^+ = 1.0$, N = 11 (10 ties), P = 1.000; 2/8 versus 8/2 – $T^+ = 6.0$, N = 11 (8 ties), P = 0.250; 2/8 versus 10/0 – $T^+ = 11.0$, N = 11 (6 ties), P = 0.500; 5/5 versus 8/2 – $T^+ = 10.0$, N = 11 (7 ties), P = 0.125; 5/5 versus 10/0 – $T^+ = 10.0$, N = 9 (5 ties), P = 0.125; 8/2 versus 10/0 – $T^+ = 11.0$, N = 11 (6 ties), P = 0.375).

Probe trials were used to determine whether proposers and responders could discriminate between the different quantities, to inhibit pulling and to attend to food available to their partners. For proposers, there was no difference in choices between probe and test for any of the payoff options (2/8 – $T^+ = 5.0$, N = 11 (7 ties), P = 1.000; 5/5 – $T^+ = 19.00$, N = 11 (3 ties), P = 0.945; 10/0 – $T^+ = 31.50$, N = 11 (1 tie), P = 0.717; Fig. S1), meaning that they did not adjust their choices to the responders. Proposers were able to discriminate among the quantities by choosing the larger amount for themselves in the 8/2 ($t_{10} = 6.274$, $P < 0.001$) and 5/5 conditions ($t_{10} = 3.092$, P = 0.011), but not in the 10/0 condition ($t_{10} = 0.394$, P = 0.702).

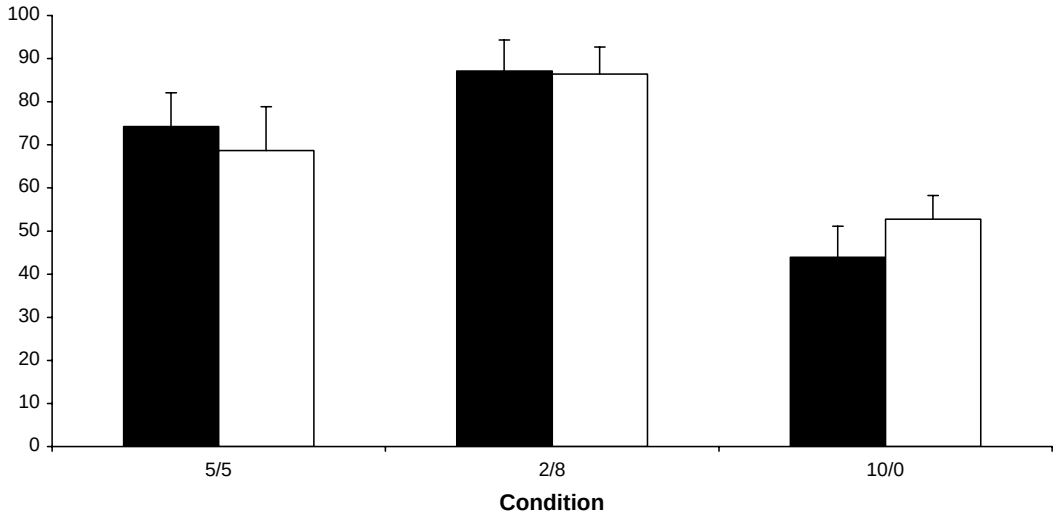

Fig. S1. Percentage of trials (mean ± sem) in which proposers chose the maximizing offer (8/2 in the 5/5 condition, 8/2 in the 2/8 condition and 10/0 in the 10/0 condition). The 8/2 condition is not shown since there was no choice for the proposer. Social (game) trials are shown in black and non-social (probe) trials are in white.

Responders were above chance (50%) in all discrimination probes (2/8 – t_{10} = 7.904, P < 0.001; 5/5 – t_{10} = 7.640, P < 0.001; 10/0 options were chosen correctly 100% of the time; Fig. S2). Furthermore, responders were capable of inhibiting pulling as demonstrated by rejections of 10/0 offers in the test, as well as non-social inhibition probe trials in which the proposer's trays were baited but the responders could not reach any food (inhibition on 63.64 ± 10.73% of probe trials).

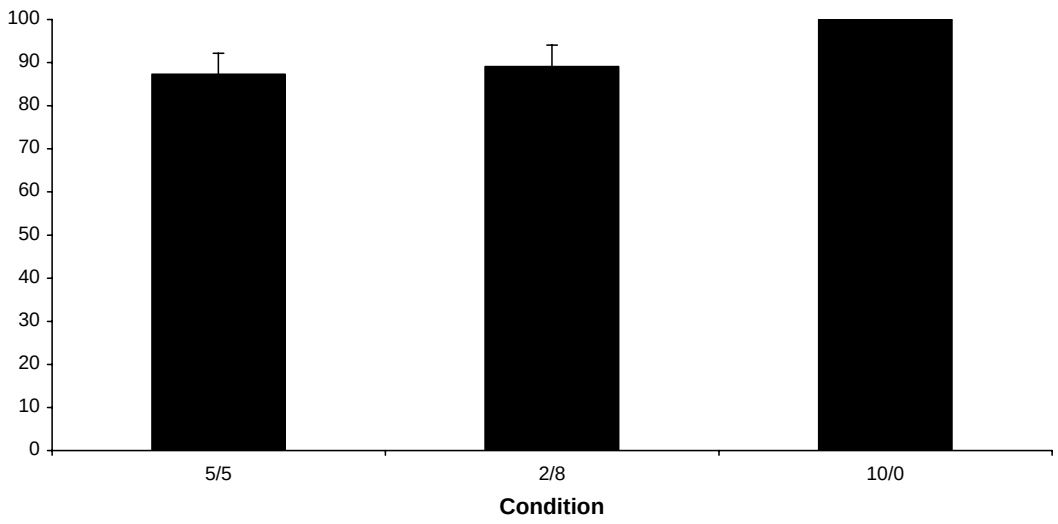

Fig. S2. Percentage of trials (mean ± sem) in which responders chose the maximizing tray in the non-social probe trials (5/5 in the 5/5 condition, 2/8 in the 2/8 condition and 8/2 in the 10/0 condition). There was no choice to be made in the 8/2 condition therefore those results are not shown here.

In a follow-up study, subjects were tested individually in the role they had played last to determine whether they could attend to food in the dish not normally accessible to them. As a group, chimpanzees were able to see the food in the opposite dish (63.64 ± 4.39% correct, t_{10} = 3.105, P = 0.011) demonstrating that they were potentially able to attend to amount of food in the partner's dish during the test; however, whether or not they actually *did* attend to payoffs to others on each trial cannot be conclusively determined.

References

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